Lake Water Quality Assessment for the Jamestown Reservoir Stutsman County, North Dakota

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SUMMARY

Jamestown Reservoir is a 1,200-acre impoundment on the James River in Stutsman County, North Dakota. The dam was constructed by the U.S. Bureau of Reclamation for municipal water supply, flood control and recreation. The reservoir water storage is jointly managed by the U.S. Bureau of Reclamation and U.S. Army Corps of Engineers. In brief, water storage for irrigation and municipal uses is managed by the Bureau, and flood control is managed by the Corps.

The dam structure lies within the city limits of Jamestown and backs up water for approximately 8 miles to the north along the relatively narrow James River flood plain. The reservoir at normal pool has a maximum depth of more than 30 feet and a mean depth of approximately 8 feet (Figure 1).

Jamestown Reservoir's watershed is extensive, draining significant portions of Wells, Eddy, Foster and Stutsman counties. The entire watershed lies within the Glaciated Plains Ecoregion of North Dakota. The watershed is characterized by rolling and hilly glaciated plains with many small and large pothole wetlands. The James River is the largest of three main river drainages in this ecoregion.

Public facilities include two resort areas which provide fishing supplies and are equipped with camping areas, boat ramps and associated parking and concessions. There is also a park with lake front access, picnic tables, walking paths and a public beach. Access to the Jamestown Reservoir is excellent during all seasons from paved roads.

Jamestown Reservoir’s fishery is managed by the North Dakota Game and Fish Department. Management practices include tracking fish recruitment and survival, stockings of both game and forage fish species and placement of artificial habitats. In general, the fishery is good to excellent, with the largest variables affecting the fishery being water level fluctuations and out-migration.

Primary fish species managed in the Jamestown Reservoir include northern pike, walleye, yellow perch and crappie. Additionally, there are abundant populations of carp, black bullhead, white sucker and the occasional small mouth bass or bluegill.

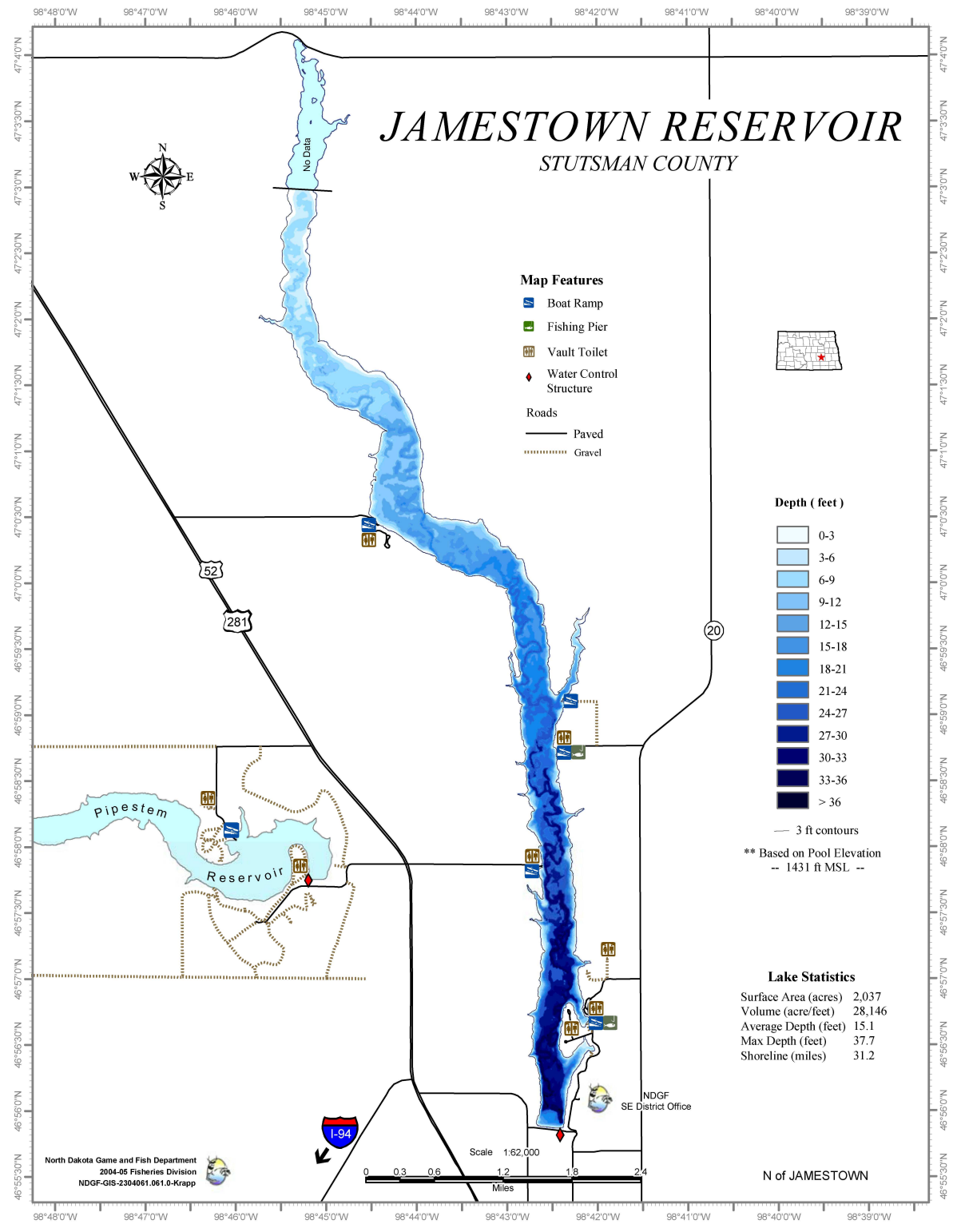

Figure 1. Map of Jamestown Reservoir

WATER QUALITY

Lake water quality assessment data was collected on the Jamestown Reservoir during the summer of 1998 and winter of 1999. Data collected included water quality chemistry and phytoplankton species identification and enumeration.

Water quality samples were collected from the reservoir on five separate dates, at three locations and at multiple depths. Sampling dates were May 13, July 22, August 19, October 14, 1998 and February 17, 1999. The sampling locations were: (1) approximately 50 meters off the dam face, (2) near mid-lake and (3) at the inlet 100 meters south of County Highway 42. All water samples were collected over the thalway. Sampling depths were ½ meter, mid-depth and ½ meter off the bottom for the near-dam and mid-lake sites, and one meter at the inlet site. Of note, water samples were not collected at the inlet site in February as there was no water present due to normal winter draw down.

At no time during the 1998-1999 water quality investigation was the Jamestown Reservoir thermally stratified (Figures 2, 3 and 4). Dissolved oxygen concentrations remained above the North Dakota Water Quality Standards of 5 milligrams per liter (mg/L) in all but three samples collected, and these were all collected at or within ½ meter of the bottom (Figures 5, 6 and 7).

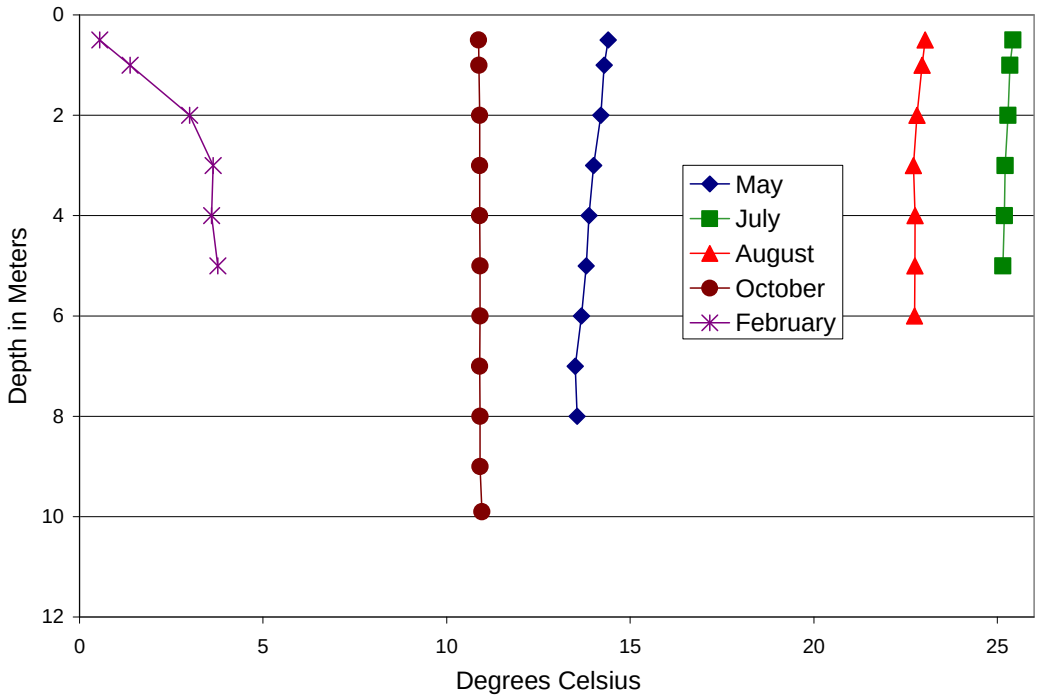

Figure 2. Jamestown Reservoir Temperature Profiles Near Dam 1998-1999

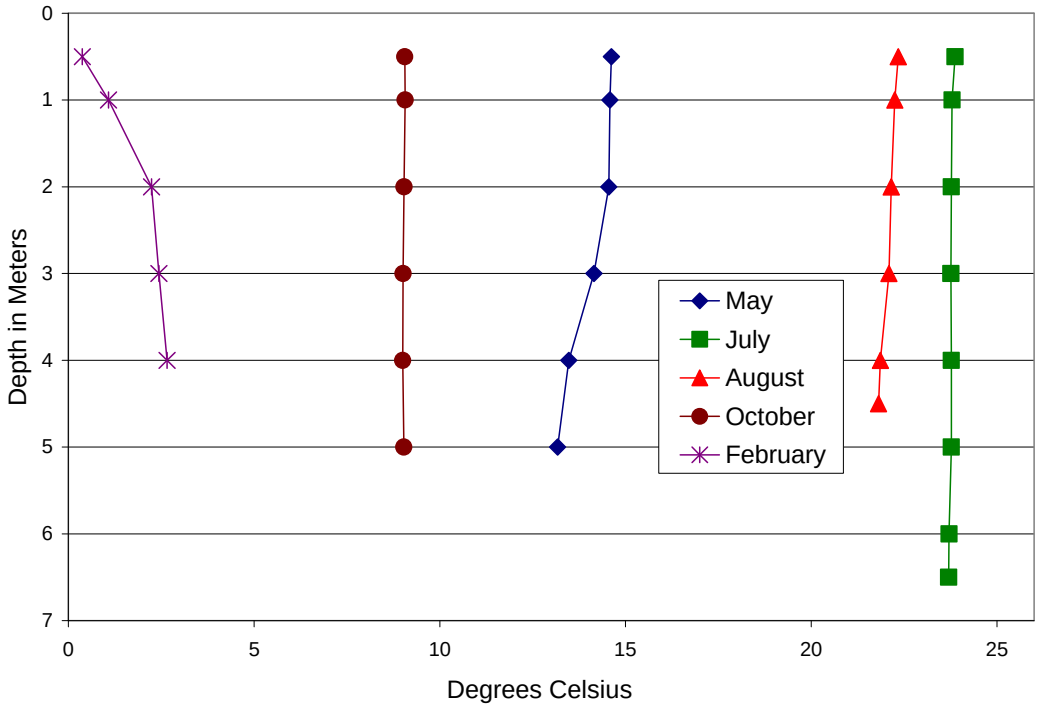

Figure 3. Jamestown Reservoir Temperature Profiles Mid-Lake 1998-1999

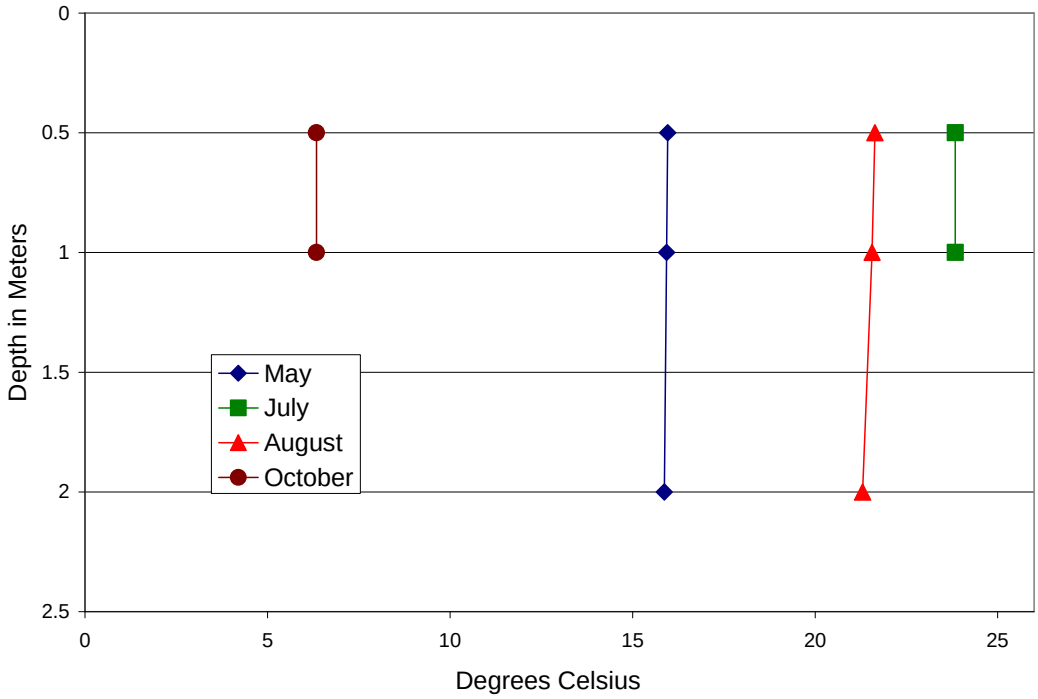

Figure 4. Jamestown Reservoir Temperature Profiles Near Inlet 1998-1999

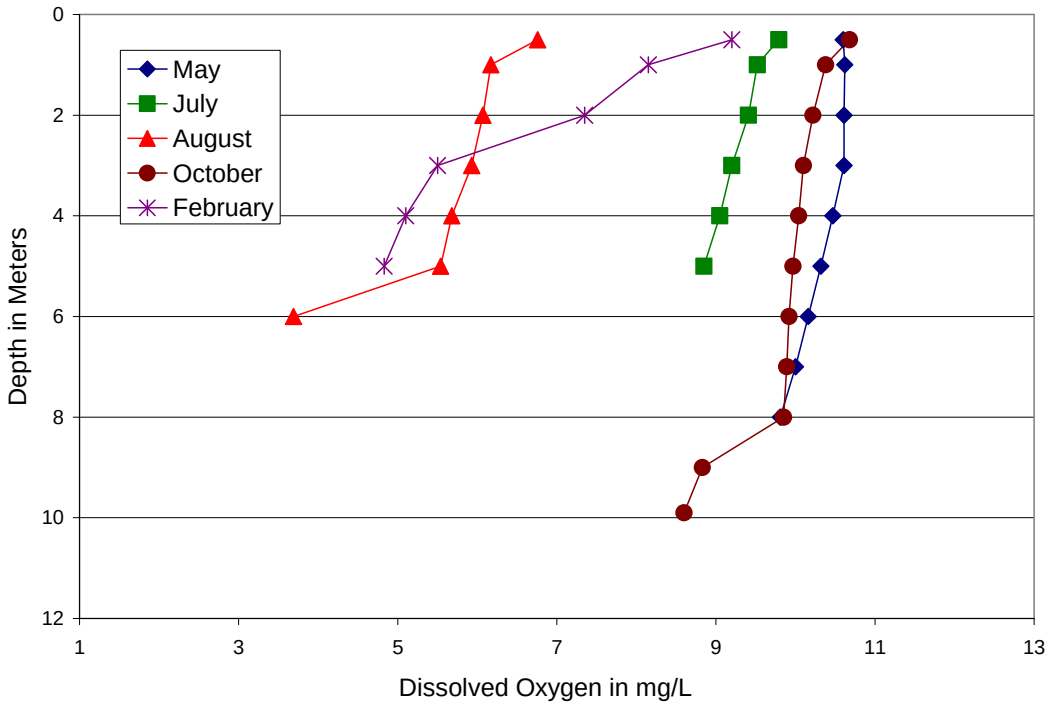

Figure 5. Jamestown Reservoir Dissolved Oxygen Profiles Near Dam 1998-1999

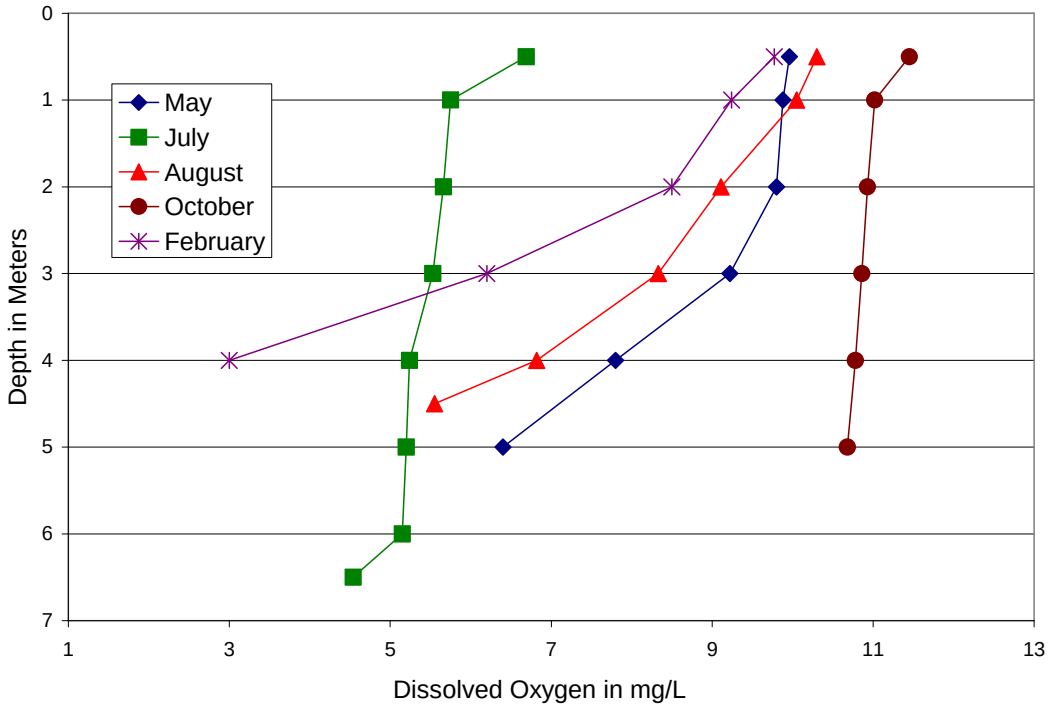

Figure 6. Jamestown Reservoir Dissolved Oxygen Profiles Mid-Lake 1998-1999

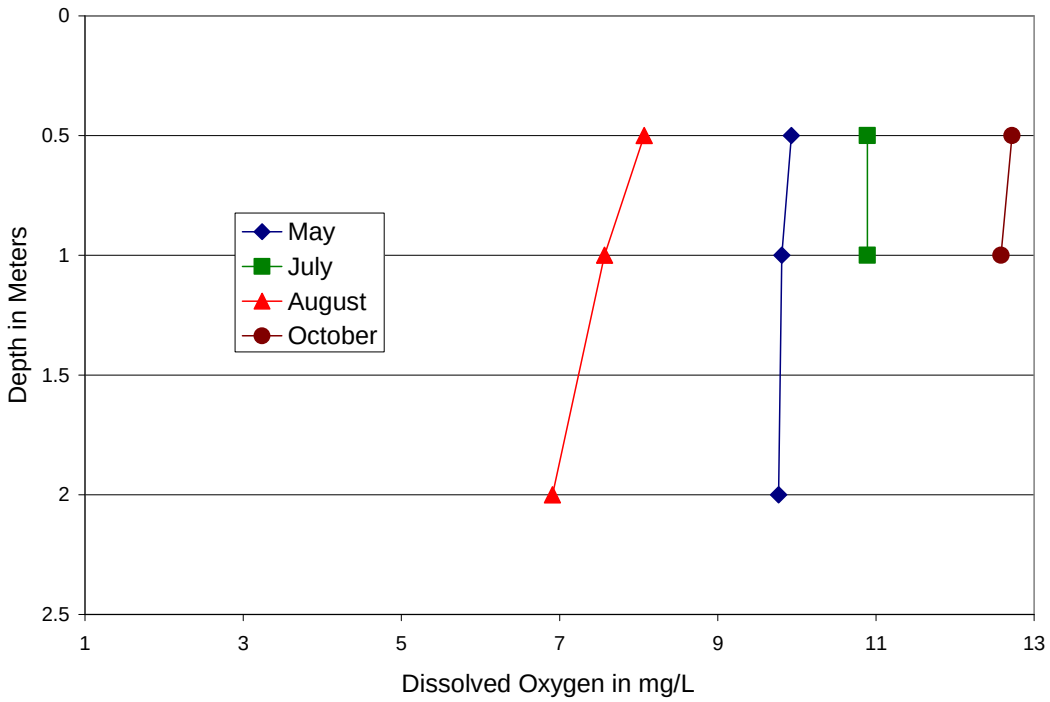

Figure 7. Jamestown Reservoir Dissolved Oxygen Profiles Near Inlet

Water quality samples collected in 1998-1999 describe the Jamestown Reservoir as a fairly well buffered reservoir that ranged from hypereutrophic at the inlet and mid-lake areas to eutrophic at the dam. Total alkalinity as calcium ranged from 102 mg/L to 264 mg/L with a volume-weighted mean at the dam of 214 mg/L.

The dominant anions within the water column are bicarbonates and sulfates. Bicarbonates ranged from 209 mg/L to 307 mg/L, with a volume weighted-mean at the dam of 243 mg/L. Sulfates ranged between 116 mg/L to 293 mg/L with a volume-weighted mean of 124 mg/L at the dam.

Nitrate + nitrite as nitrogen and total phosphorus as phosphate concentrations ranged from non-detectable to 0.030 mg/L and 0.09 mg/L to 0.645 mg L^{-1}, respectively, with volume-weighted mean concentrations near the dam of 0.020 mg/L and 0.233 mg/L. Tables 1 through 3 contain the volume-weighted means for selected parameters at all three sampling locations and the North Dakota arithmetic mean of all LWQA lakes and reservoirs sampled between 1995 and 2001.

Table 1. Jamestown Reservoir near Dam - Volume-Weighted Mean Concentrations for Select Water Quality Parameters and the North Dakota Arithmetic Mean for all Lakes Sampled Between 1995 and 2001

Parameter	Near Dam Site	1995-2002 Mean	Unit
Total Dissolved Solids	401	1545	mg/L
Hardness as Calcium	236	474	mg/L
Sulfate as SO_4	124	785	mg/L
Chlorides	12	64	mg/L
Total Alkalinity as Calcium	214	229	mg/L
Bicarbonate as HCO_3	243	274	mg/L
Conductivity	679	1984	omhos/cm
Total Phosphorus as Phosphate	0.219	0.152	mg/L
Nitrate + Nitrite as Nitrogen	0.074	0.117	mg/L
Total Ammonia as Nitrogen	0.074	0.272	mg/L
Total Kjeldahl Nitrogen	0.958	1.775	mg/L

Table 2. Jamestown Reservoir Mid-Lake - Volume-Weighted Mean Concentrations for Select Water Quality Parameters and the North Dakota Arithmetic Mean for all Lakes Sampled between 1995 and 2001

Parameter	Near Dam Site	1995-2002 Mean	Unit
Total Dissolved Solids	414	1545	mg/L
Hardness as Calcium	240	474	mg/L
Sulfate as SO_4	127	785	mg/L
Chlorides	10	64	mg/L
Total Alkalinity as Calcium	225	229	mg/L
Bicarbonate as HCO_3	256	274	mg/L
Conductivity	695	1984	omhos/cm
Total Phosphorus as Phosphate	0.286	0.152	mg/L
Nitrate + Nitrite as Nitrogen	0.057	0.117	mg/L
Total Ammonia as Nitrogen	0.113	0.272	mg/L
Total Kjeldahl Nitrogen	1.149	1.775	mg/L

Table 3. Jamestown Reservoir Near Inlet – Volume-Weighted Mean Concentrations for Select Water Quality Parameters and the North Dakota Arithmetic Mean for all Lakes Sampled between 1995 and 2001

Parameter	Near Dam Site	1995-2002 Mean	Unit
Total Dissolved Solids	429	1545	mg/L
Hardness as Calcium	231	474	mg/L
Sulfate as SO_4	127	785	mg/L
Chlorides	16	64	mg/L
Total Alkalinity as Calcium	226	229	mg/L
Bicarbonate as HCO_3	233	274	mg/L
Conductivity	696	1984	omhos/cm
Total Phosphorus as Phosphate	0.375	0.152	mg/L
Nitrate + Nitrite as Nitrogen	0.013	0.117	mg/L
Total Ammonia as Nitrogen	0.207	0.272	mg/L
Total Kjeldahl Nitrogen	1.427	1.775	mg/L

LIMITING NUTRIENT

Ratios of total nitrogen to total phosphorus ranged from 3.76 to 12.38, indicating that the Jamestown Reservoir is nitrogen limited (Figure 8). For purposes of the LWQA, a waterbody is assumed to be in nutrient equilibrium with a ratio of total nitrogen to total phosphorus of 15:1. When a lake's total nitrogen to total phosphorus ratios is less than 15:1, nitrogen is probably the controlling nutrient; when it exceeds 15 the controlling nutrient is probably phosphorus. When nitrogen becomes the limiting nutrient, primary production is usually not limited but altered. The altered condition favors certain species of primary producers that are either able to affix nitrogen, utilize organic nitrogen or are tolerant of low nitrogen conditions.

TROPHIC STATUS

During the 1998-1999 investigation, the Jamestown Reservoir's trophic status was assessed as hypereutrophic in the upper reaches of the reservoir and eutrophic in the lower reaches. Trophic status is an estimation of a lake's or reservoir's productivity. In general, as a lake ages it becomes more productive. When this maturing process reaches an advanced stage, it is known as hypereutrophic. This state is usually identified by a loss of lake depth through sedimentation, a decline in aesthetics due to frequent algal blooms and a reduction in the amount and types of aquatic life it can support. When a lake is hypereutrophic, it often smells badly, suffers frequent fish kills and experiences rapid oxygen depletion during thermal stratification and under ice-cover conditions. Reservoirs which inundate large areas of deep fertile soils are especially susceptible to rapid eutrophication and often begin in an over-productive condition.

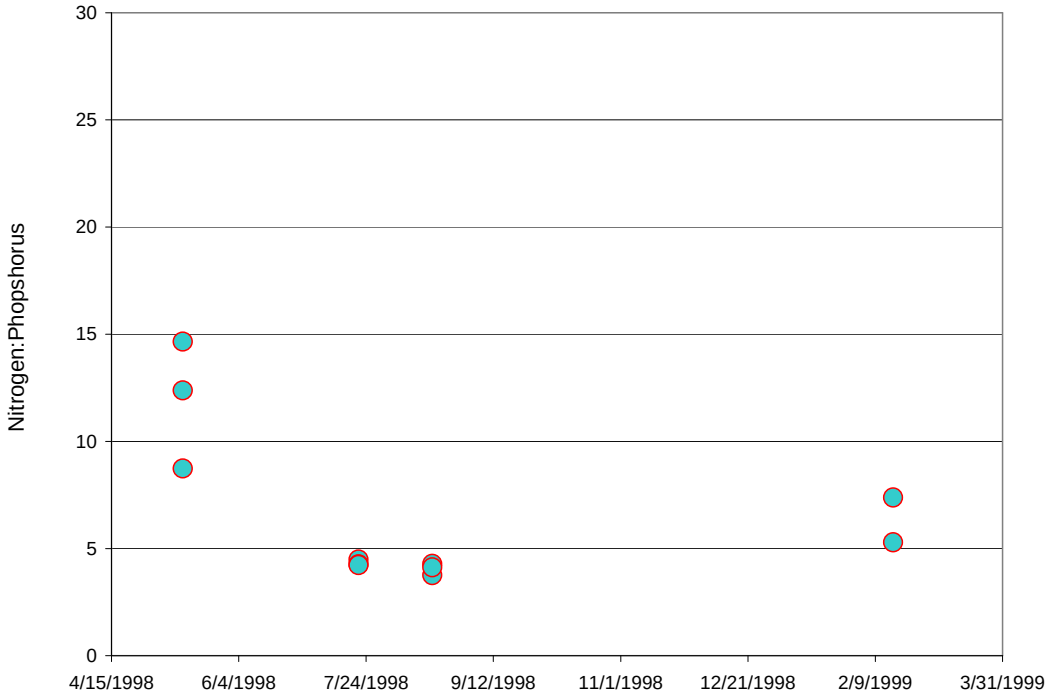

Figure 8. Total Nitrogen to Total Phosphorus Ratios

For purposes of this project, trophic status is measured using Carlson's Trophic Status Index (TSI) (Carlson 1977). Carlson's TSI was selected because of its common use among limnologists and because it was developed for lakes in Minnesota, a state close to North Dakota geographically.

Carlson's TSI uses a mathematical relationship based on secchi disk transparency, concentrations of total phosphorus at the surface and chlorophyll-a concentrations. This numerical value then corresponds to a trophic condition ranging from 0 to 100 with increasing values indicating a more eutrophic condition (Figure 9). TSI scores for the Jamestown Reservoir ranged between a low of 55 at the dam to a high of 85 at the inlet. Mean TSI scores for the three areas sampled were 62.5 at the dam, 71.7 at mid-lake and 78.7 at the inlet.

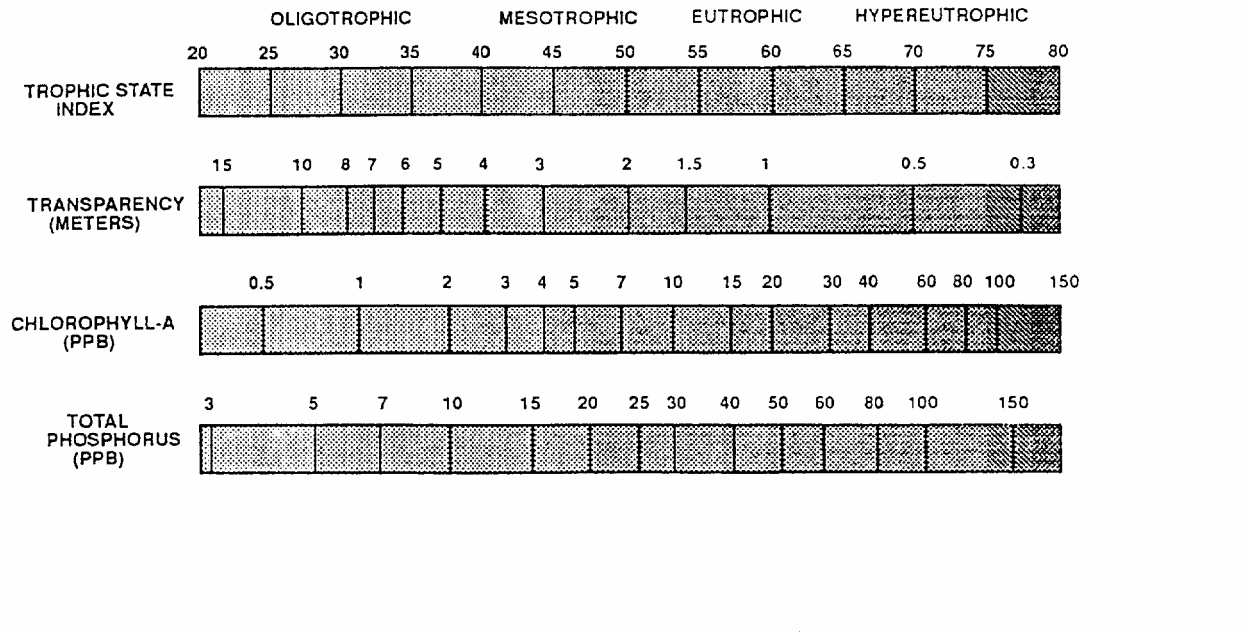

Figure 9. Graphic Depiction of Carlson's Trophic Status Index

PHYTOPLANKTON

Phytoplankton can be used as indicators of nutrient availability and trophic condition. Jamestown Reservoir's phytoplankton community was sampled four times at all three monitoring locations during the summer of 1998. Sampling dates were May 13, July 22, August 18 and October 14, and sampling locations were at the inlet, at mid-lake and near the dam.

Samples collected in 1998 show that Jamestown Reservoir's phytoplankton community is large and diverse with representation from seven orders and 129 genera. Densities ranged from 38,717 to 1,257,064 cells per milliliter with the order Cyanophyta dominating more than 82 percent of the phytoplankton population density. The next largest contributor to the phytoplankton community by density was Chlorophyta, followed by Bacillariophyta, Cryptophyta, Pyrrophyta, Chrysophyta and Euglenophyta.

The phytoplankton population enumerations by volume were very different than density as the large organisms in the division Pyrrophyta displaced the greatest volume at the mid-lake and near-dam sites, and Chlorophyta displaced the greatest volume at the inlet. More than 86 percent of the phytoplankton volume at the mid-lake and near-dam sites were occupied by the division Pyrrophyta, while Chlorophyta occupied 48 percent at the inlet site.